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Kawasaki et al.

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(54) **HIGH VOLTAGE DEVICE SYSTEM OF RAILCAR AND RAILCAR**

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CPC B61G 5/10; B60D 1/64; H02G 15/08; B60L 5/24; H01R 4/00
See application file for complete search history.

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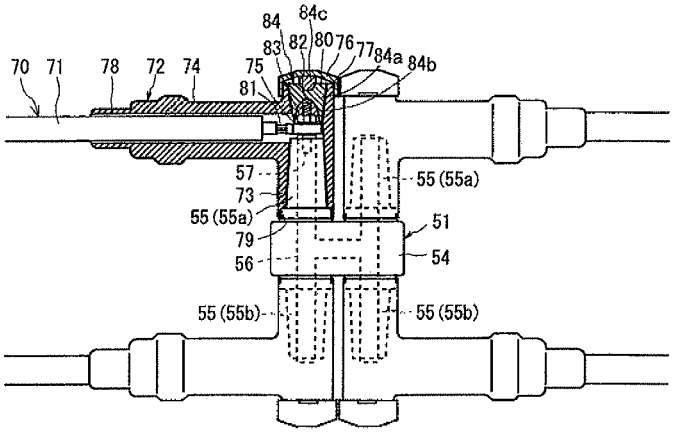
(57) **ABSTRACT**

The present invention is a high voltage device system mounted on a railcar and includes a plurality of high voltage devices to which high-voltage electric power from an overhead contact line is supplied, a plurality of high-voltage cables configured to connect the high voltage devices with each other, and a joint device to which the high-voltage cables are connected. The high-voltage cables respectively include cable connector portions at tip end portions thereof, and each of the cable connector portions includes a base tubular portion configured to cover the high-voltage cable and a fit tubular portion extending from the base tubular portion in a direction substantially perpendicular to a longitudinal direction of the high-voltage cable. The joint device includes joint connector portions, each of which is fitted to the fit tubular portion of the cable connector portion to be connected to the high-voltage cable.

11 Claims, 4 Drawing Sheets



(51) **Int. Cl.**
B61G 5/10 (2006.01)
B60L 5/24 (2006.01)

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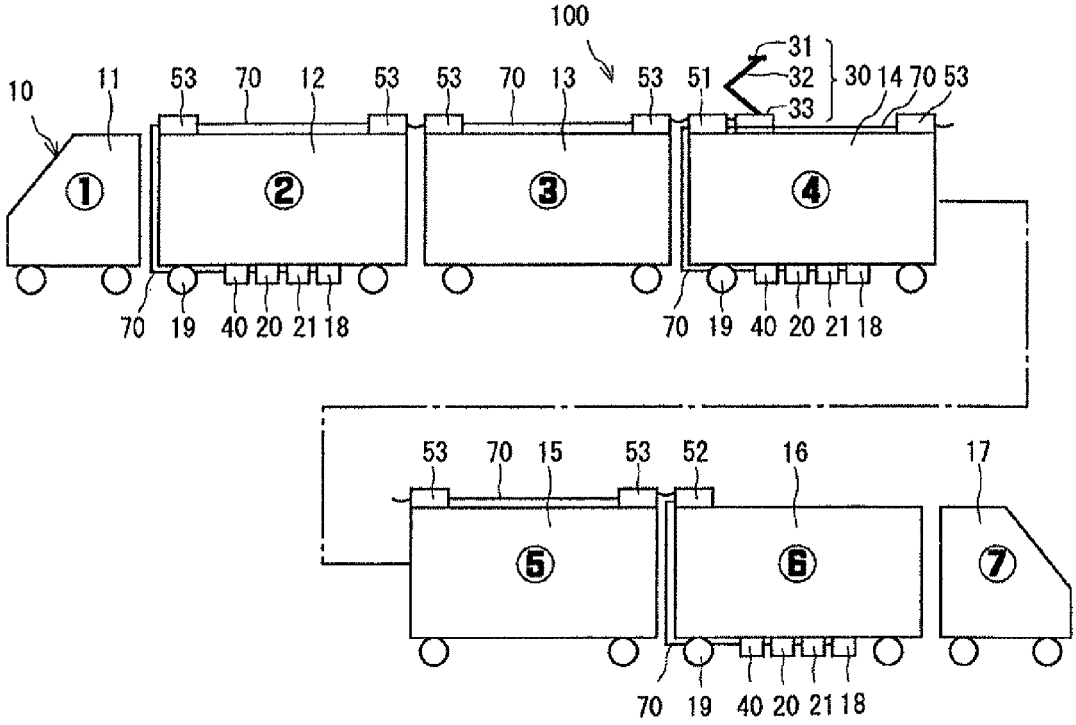
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Fig. 1

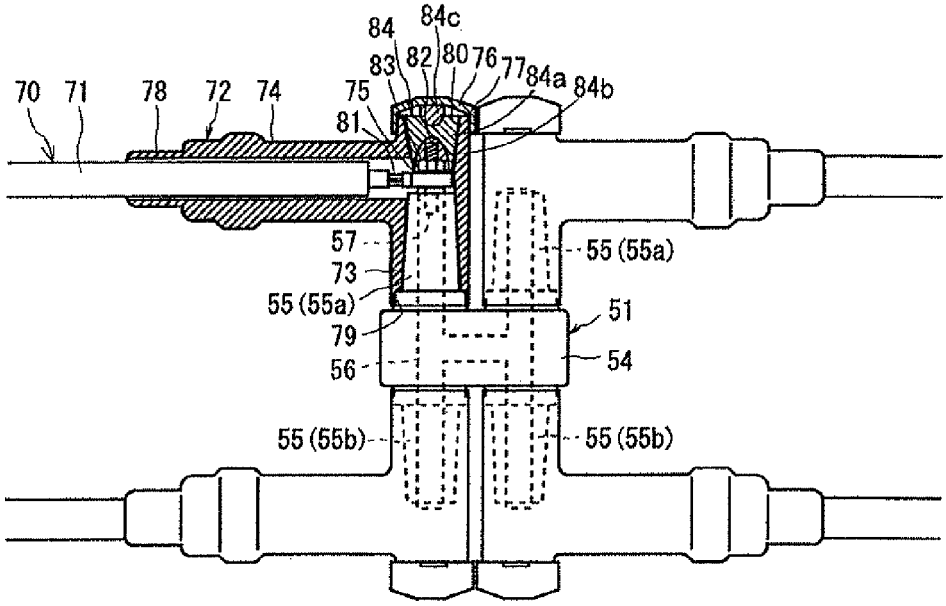
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Fig. 2

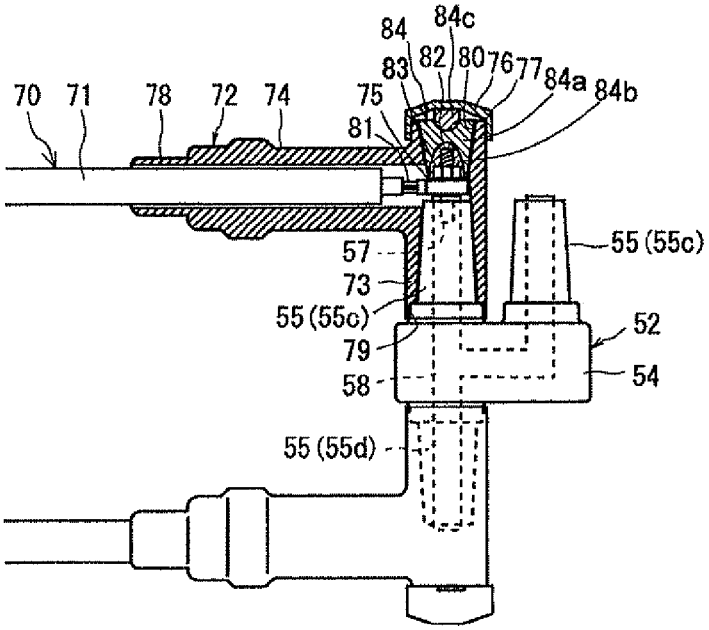
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Fig. 3

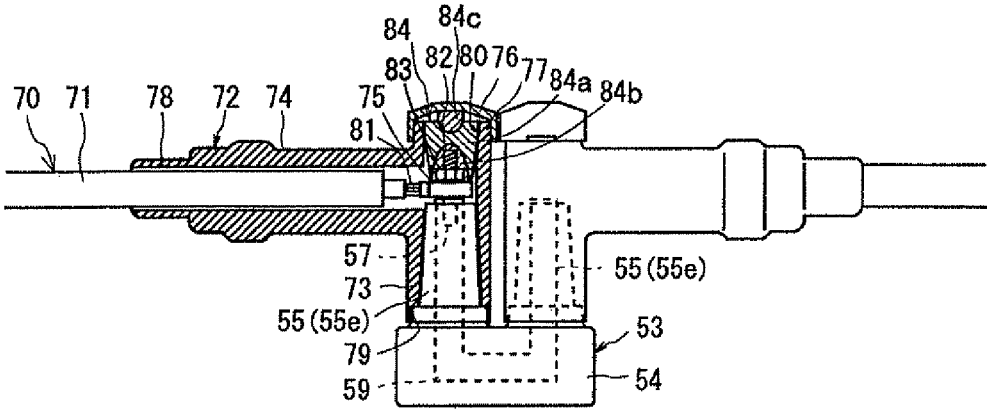
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Fig. 4

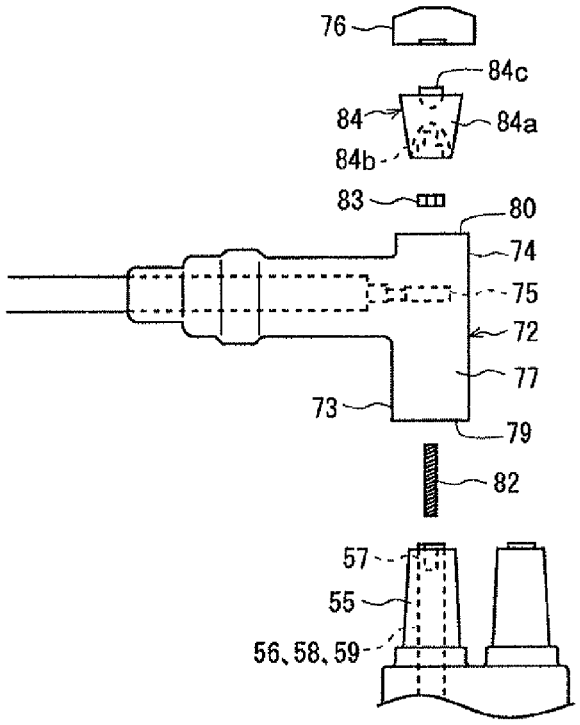
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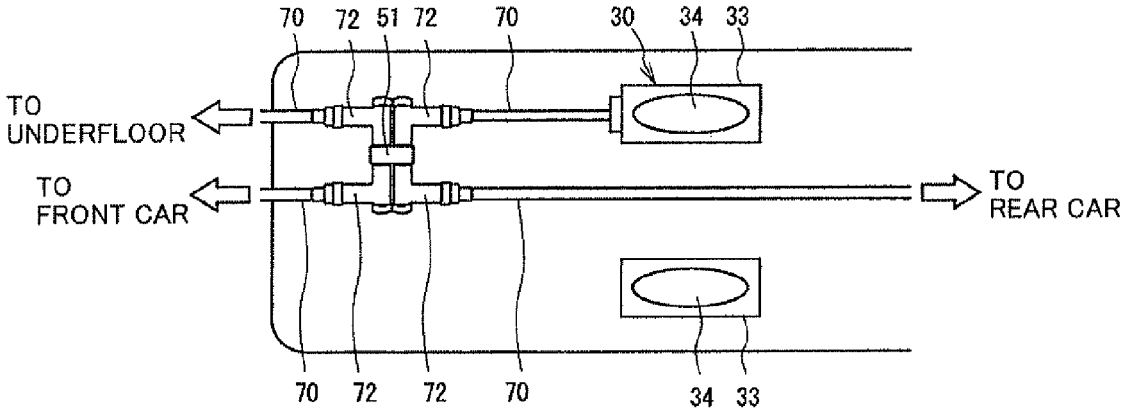
Fig. 5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TO
UNDERFLOOR
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FRONT CAR
TO
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Fig. 6

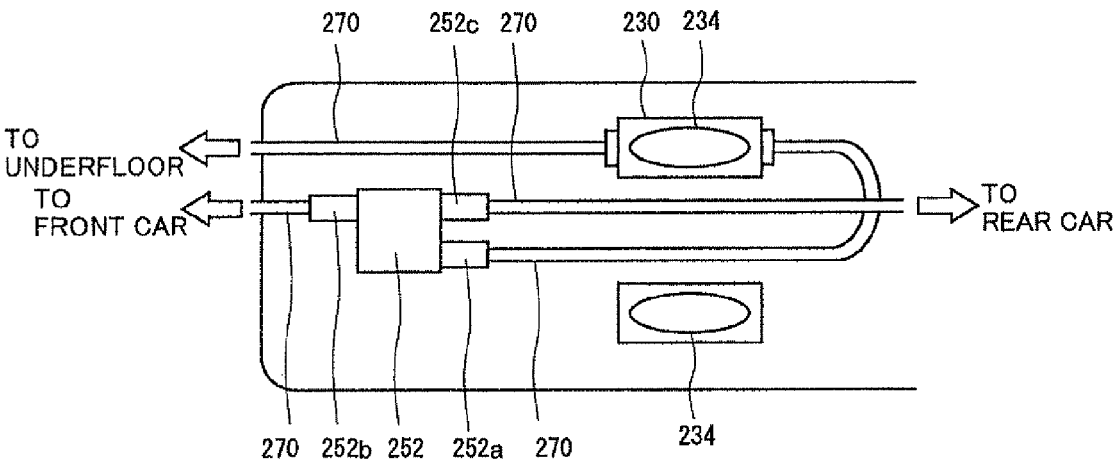

Fig. 7

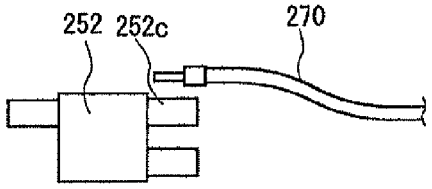

Fig. 8A

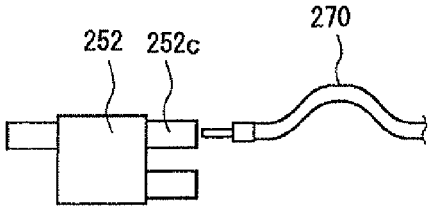

Fig. 8B

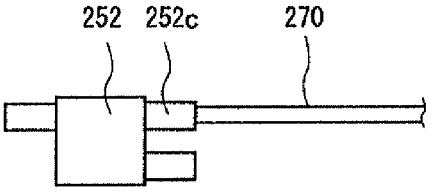

Fig. 8C

HIGH VOLTAGE DEVICE SYSTEM OF RAILCAR AND RAILCAR

TECHNICAL FIELD

The present invention relates to a high voltage device system mounted on a railcar and a railcar including the high voltage device system.

BACKGROUND ART

To receive high-voltage electric power through an overhead contact line and supply the electric power to respective devices of a railcar, the railcar includes on an upstream side a plurality of high voltage devices, such as a power collector (pantograph), a vacuum circuit breaker (VCB), a lightning arrester (arrester), and a transformer. Then, a high voltage device system is constituted by these high voltage devices, high-voltage cables interposed among the high voltage devices, a joint device configured to connect the high-voltage cables with one another, and the like.

As conventional joint devices, two types that are a straight joint device and a Y branch joint device are known. The straight joint device connects two high-voltage cables with each other in a straight manner whereas the Y branch joint device connects three high-voltage cables with one another.

FIG. **7** shows the vicinity of a power collector arranged on a roof of a railcar and using a Y branch joint device. In FIG. **7**, a collector shoe and arm portion of the power collector are omitted. Two high-voltage cables **270** respectively extend from front and rear sides of a power collector **230** in a railcar longitudinal direction. One of the high-voltage cables **270** is connected to a vacuum circuit breaker arranged under a floor of a car, and the other high-voltage cable **270** is connected to a receiving opening **252***a* of a Y branch joint device **252**. In the Y branch joint device **252**, the high-voltage cable **270** branches into two cables. One of the two cables is connected to a receiving opening **252***b* of the Y branch joint device **252** and extends toward a front-side car, and the other cable is connected to a receiving opening **252***c* of the Y branch joint device **252** and extends toward a rear-side car. Thus, the electric power is supplied to the respective ears.

In a case where the high-voltage cable **270** is connected to the Y branch joint device **252**, a so-called prefabricated joint (see PTL 2) is adopted in the high voltage device system of the railcar, the prefabricated joint being configured such that: a rubber stress-relief cone (not shown) arranged at a terminal of the high-voltage cable **270** is inserted into the receiving opening of the Y branch joint device **252** which is made of epoxy resin and the like and in which an internal conductor (not shown) is embedded; and the stress-relief cone is pressed against the receiving opening by a compression unit (not shown).

PTL 1 discloses an electric power cable connecting device using a conventional joint device. FIG. 2 of PTL 1 discloses a configuration corresponding to a straight joint device to which the prefabricated joint is applied and which is for use in the railcars.

PTL 2 discloses a prefabricated joint. FIGS. 6 and 8 of PTL 2 disclose a configuration corresponding to a Y branch joint device to which the prefabricated joint is applied.

CITATION LIST

Patent Literature

PTL 1: Japanese Laid-Open Patent Application Publication No. 6-70442

PTL 2: Japanese Laid-Open Patent Application Publication No. 2001-177975

SUMMARY OF INVENTION

Technical Problem

The following will explain in detail a conventional method of inserting a tip end of the high-voltage cable into a joint device to which the prefabricated joint is applied. FIGS. **8**A to **8**C are diagrams showing a connecting method using a conventional joint device. To be specific, in a case where the terminal of the high-voltage cable **270** is inserted into the receiving opening **252***c* of the Y branch joint device **252** to which the prefabricated joint is applied as shown in FIG. **8**A, the stress-relief cone and so on attached to the terminal of the high-voltage cable **270** that has been stripped stepwise in advance needs to be inserted into the receiving opening **252***c*. Therefore, before inserting the high-voltage cable **270**, the high-voltage cable **270** is bent once as shown in FIG. **8**B to be pulled back in a longitudinal direction, and then is coupled to the Y branch joint device **252** as shown in FIG. **8**C. However, the high-voltage cable used in the high voltage device system of the railcar is extremely large in diameter, that is, about 50 to 60 mm or more in diameter, and is extremely hard. Therefore, the work of pulling back the high-voltage cable in the longitudinal direction as shown in FIG. **8**B is not easy, and the efficiency of the work is not good.

Further, in a case where the high-voltage cable is short, the high-voltage cable cannot be coupled to the joint device. Therefore, as shown in FIG. **7**, in a case where the power collector **230** and the Y branch joint device **252** are arranged close to each other, a portion, connected to the power collector **230**, of the high-voltage cable **270** that connects the power collector **230** and the Y branch joint device **252** is arranged away from the Y branch joint device **252**. To be specific, the length of the high-voltage cable **270** that connects the power collector **230** and the Y branch joint device **252** is intentionally increased as the countermeasure (in FIG. **7**, the high-voltage cable **270** is arranged so as to U-turn). In this configuration, since the high-voltage cable increases in length, one disadvantage is that the railcar increases in weight as a whole, and another disadvantage is that a space for arranging the respective high voltage devices further decreases.

The present invention was made to solve the above problems, and an object of the present invention is to provide a high voltage device system of a railcar, the high voltage device system being capable of efficiently connecting a high-voltage cable to a joint device even at a limited space, such as a space on a roof of a railcar.

Solution to Problem

The present invention was made to solve the above problems, and a high voltage device system of a railcar according to the present invention is a high voltage device system mounted on a railcar, the high voltage device system including: a plurality of high voltage devices to which high-voltage electric power from an overhead contact line is supplied; a plurality of high-voltage cables configured to connect the high voltage devices with one another; and a joint device to which the high-voltage cables are connected, wherein: the high-voltage cables respectively include cable connector portions at tip end portions thereof, each of the cable connector portions including a base tubular portion configured to cover the high-voltage cable and a fit tubular portion extending from the base tubular portion in a direction substantially

perpendicular to a longitudinal direction of the high-voltage cable; and the joint device includes joint connector portions, each of which is fitted to the fit tubular portion of the cable connector portion to be connected to the high-voltage cable.

According to the above configuration, the high-voltage cable can be attached to the joint device by fitting the cable connector portion to the joint connector portion in a direction substantially perpendicular to a longitudinal direction of the high-voltage cable. Therefore, without performing the work of pulling back the high-voltage cable in the longitudinal direction as in the case of the prefabricated joint, the high-voltage cable can be connected to the joint device.

Advantageous Effects of Invention

According to the high voltage device system of the railcar of the present invention, the high-voltage cable can be connected to the joint device without performing the work of pulling back the high-voltage cable in the longitudinal direction. Therefore, the high-voltage cable can be efficiently connected to the joint device even in a limited space, such as a space on the roof of the railcar.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a schematic side view showing a high voltage device system and railcar according to an embodiment of the present invention.

FIG. **2** is a partially cross-sectional plan view of an X branch joint device according to the embodiment of the present invention.

FIG. **3** is a partially cross-sectional plan view of a Y branch joint device according to the embodiment of the present invention.

FIG. **4** is a partially cross-sectional plan view of a straight joint device according to the embodiment of the present invention.

FIG. **5** is an exploded view showing the vicinity of a joint connector portion and cable connector portion according to the embodiment of the present invention.

FIG. **6** is a plan view showing the vicinity of a power collector according to the embodiment of the present invention and a diagram in which a collector shoe and arm portion of the power collector are omitted.

FIG. **7** is a plan view showing the vicinity of a power collector in a conventional high voltage device system and is a diagram in which a collector shoe and arm portion of the power collector are omitted.

FIGS. **8**A to **8**C are diagrams showing one example of a method of connecting a high-voltage cable to a joint device in a conventional high voltage device system.

DESCRIPTION OF EMBODIMENTS

Hereinafter, an embodiment of a high voltage device system of a railcar according to the present invention will be explained in reference to the drawings. In the following explanation and the drawings, the same reference signs are used for the same or corresponding components, and a repetition of the same explanation is avoided.

Configuration of Railcar

The configuration of a railcar **10** on which a high voltage device system **100** according to the present embodiment is mounted will be explained in reference to FIG. **1**. FIG. **1** is a schematic side view showing the high voltage device system **100** and railcar **10** according to the present embodiment. The railcar **10** of the present embodiment includes a total of seven cars that are a first car **11**, a second car **12**, . . . , and a seventh car **17** as shown in this order from the left in FIG. **1**. The railcar **10** can travel in both left and right directions in FIG. **1**. Each of the first ear **11** and the seventh car **17** may be used as a front car. In the following explanation, for convenience sake, the left side in FIG. **1** corresponds to a proceeding direction, that is, the first car **11** is the front car. Further, in the following explanation, the "right" denotes a right-hand side when facing in the proceeding direction, the "left" denotes a left-hand side when facing in the proceeding direction, the "front" denotes a front side when facing in the proceeding direction, and the "rear" denotes a rear side when facing in the proceeding direction.

In the railcar **10** of the present embodiment, motors **18** are respectively mounted on the second car **12**, the fourth car **14**, and the sixth car **16**, and a power collector **30** is mounted on the fourth car **14**.

The power collector **30** receives a 25,000V (volt) AC (alternate current) electric power through an overhead contact line. The electric power flows through a plurality of high-voltage cables **70**, is, for example, transformed, and is then supplied to the motors **18** mounted on the second car **12**, the fourth car **14**, and the sixth car **16**. With this, the respective motors **18** drive to rotate drive wheels **19**, so that the railcar **10** can travel. In the present embodiment, the voltage supplied through the overhead contact lines is 25,000V AC. However, the present embodiment is not limited to this, and is applicable to any electrification systems adopted at respective regions.

Each of the cars **11** to **17** includes bogies arranged under a floor of the car and configured to support a carbody. In FIG. **1**, only the wheels are simply shown, and the bogies (underframes) are not shown. However, as can be understood from the wheels shown, the bogies are actually, respectively arranged at front and rear portions of each of the cars **11** to **17**. The structure of the bogie is not especially limited, but the bogie of the present embodiment is configured such that at least a center thereof supports the carbody.

High Voltage Device System

Next, the configuration of the high voltage device system **100** according to the present embodiment will be explained in reference to FIGS. **1** to **4**. As shown in FIG. **1**, the high voltage device system **100** of the present embodiment includes a plurality of high voltage devices to which high-voltage electric power is supplied through the overhead contact line. As shown in FIG. **1**, the high voltage device system **100** according to the present embodiment includes the power collector **30**, breakers **40**, and transformers **20** as the high voltage devices and further includes joint devices **51** to **53** and high-voltage cables **70**. The power collector **30** and the joint devices **51** to **53** are arranged on a roof of the railcar **10**, and the breakers **40** and the transformers **20** are arranged under a floor of the railcar **10**. Hereinafter, these components will be explained in order.

The power collector **30** is a high voltage device configured to collect high-voltage electric power through the overhead contact line. As described above, in the present embodiment, the power collector **30** is mounted only on the fourth car **14**. The power collector **30** is mounted at a front portion on the roof of the fourth car **14**. As above, the power collector is generally located at a front portion or rear portion on a roof of a car. To be specific, the power collector **30** is provided at a position above the center of the bogie, that is, a position where the change in position relative to the overhead contact line becomes minimum. The power collector **30** of the present embodiment is a so-called pantograph and is mainly constituted by a collector shoe **31** contacting the overhead contact line, an arm portion **32** configured to move the collector shoe

31 upward and downward, a supporting member 33 configured to support the arm portion 32, and column portions 34 respectively provided on left and right sides of the supporting member 33 (see FIG. 6).

Each of the breakers 40 is a high voltage device configured to cut off a high current to prevent devices from being damaged when the high current flows through the respective devices and cables. To be specific, the breaker 40 is a high voltage device configured to break a circuit if a predetermined current or a current higher than the predetermined current flows from the power collector 30. To secure its function, the breaker 40 is provided upstream of the devices, such as the motor 18 (in fact, the breaker 40 is provided between the power collector 30 and the transformer 20). In the present embodiment, the breakers 40 are respectively mounted on the second car 12, the fourth car 14, and the sixth car 16, on each of which the transformer 20 configured to transform the voltage of the current having flowed through the breaker 40 is mounted. In the present embodiment, to suppress the influences by air resistance during traveling, the breakers 40 are respectively arranged under the floors of the cars 12, 14, and 16. The breakers 40 may be respectively arranged on the roofs of the cars 12, 14, and 16. In the present embodiment, the breaker 40 is a vacuum circuit breaker (VCB). However, the type and the like of the breaker is not especially limited, and an air blast breaker (ABB) or the like may be used. The current having flowed through the breaker 40 flows through the transformer 20, so that the voltage thereof is reduced to a predetermined voltage value. Then, the frequency of the current is converted by a main converter 21, and the current flows to the motor 18.

The joint devices 51 to 53 are devices configured to connect the high-voltage cables 70 with one another. In the high voltage device system 100 according to the present embodiment, three types of joint devices that are an X branch joint device 51, a Y branch joint device 52, and a straight joint device 53 are used. The configurations of the respective joint devices 51 to 53 are as follows.

The X branch joint device 51 is a device to which four high-voltage cables can be connected and by which the electric power supplied through one high-voltage cable can be supplied to the other three high-voltage cables. As shown in FIG. 1, the X branch joint device 51 is located on the roof of the fourth car 14 and on the front side of the power collector 30. Here, FIG. 2 is a partially cross-sectional plan view showing the X branch joint device 51 according to the present embodiment. The left side in FIG. 2 is the front side, the right side in FIG. 2 is the rear side, the upper side in FIG. 2 is the right side, and the lower side in FIG. 2 is the left side (the same is true in FIGS. 3, 4, and 6). As shown in FIG. 2, the X branch joint device 51 is mainly constituted by a base portion 54 located at the center thereof, four joint connector portions 55 each formed in a convex shape, and an H-shaped internal conductor portion 56 embedded therein. Each of the joint connector portions 55 has a tapered columnar shape, and a below-described cable connector portion 72 is fitted to the joint connector portion 55. The four joint connector portions 55 are two first joint connector portions 55*a* and two second joint connector portions 55*b*. Each of the first joint connector portions 55*a* projects from the base portion 54 toward one side (right side) in a railcar width direction, and each of the second joint connector portions 55*b* projects from the base portion 54 toward the other side (left side) in the railcar width direction. The first joint connector portions 55*a* are lined up in a front-rear direction, and the second joint connector portions 55*b* are lined up in the front-rear direction. The internal conductor portion 56 is exposed from tip ends of the joint connector portions 55, and internal threads 57 are respectively formed at exposed tip end portions of the internal conductor portion 56.

The Y branch joint device 52 is a device to which three high-voltage cables 70 can be connected and by which the electric power supplied through one high-voltage cable can be supplied to the other two high-voltage cables. As shown in FIG. 1, the Y branch joint device 52 is arranged at the front portion on the roof of the sixth car 16. Here, FIG. 3 is a partially cross-sectional plan view showing the Y branch joint device 52 according to the present embodiment. As shown in FIG. 3, the Y branch joint device 52 is mainly constituted by the base portion 54 located at the center thereof, three joint connector portions 55 each formed in a convex shape, and an internal conductor portion 58 embedded therein. Each of the joint connector portions 55 has a tapered columnar shape, and the below-described cable connector portion 72 is fitted to the joint connector portion 55. The three joint connector portions 55 are two third joint connector portions 55*c* and one fourth joint connector portion 55*d*. The third joint connector portions 55*c* project from the base portion 54 toward one side (right side) in the railcar width direction and are respectively arranged at front and rear sides in the railcar longitudinal direction. One fourth joint connector portion 55*d* projects from the base portion 54 toward the other side (left side) in the railcar width direction. The Y branch joint device 52 of the present embodiment is configured such that two joint connector portions 55 (third joint connector portions 55*c*) project on the right side, and one joint connector portion 55 (fourth joint connector portion 55*d*) projects on the left side. However, on the contrary, the Y branch joint device 52 may be configured such that one joint connector portion 55 projects on the right side, and two joint connector portions 55 project on the left side. The internal conductor portion 58 is exposed from tip ends of the joint connector portions 55, and the internal threads 57 are respectively formed at exposed tip end portions of the internal conductor portion 58.

The straight joint device 53 is a device capable of connecting two high-voltage cables 70 in a straight manner. As shown in FIG. 1, the straight joint devices 53 are respectively arranged at both the front and rear portions on the roofs of the second car 12, the third car 13, and the fifth car 15 and at the rear portion on the roof of the fourth car 14. Here, FIG. 4 is a partially cross-sectional plan view showing the straight joint device 53 according to the present embodiment. As shown in FIG. 4, the straight joint device 53 is mainly constituted by the base portion 54, two joint connector portions 55 (fifth joint connector portions 55*e*) each formed in a convex shape, and a U-shaped internal conductor portion 59 embedded therein. Each of the joint connector portions 55 has a tapered columnar shape, and the below-described cable connector portion 72 is fitted to the joint connector portion 55. The two fifth joint connector portions 55*e* project from the base portion 54 toward one side (right side) in the railcar width direction and are lined up in the front-rear direction. In the straight joint device 53 of the present embodiment, the two fifth joint connector portions 55*e* project from the base portion 54 toward the right side. However, the direction of the projection is not especially limited. For example, the two joint connector portions 55 may project from the base portion 54 toward the left side or the upper side. The internal conductor portion 59 is exposed from the tip ends of the joint connector portions 55, and the internal screws 57 are respectively formed at exposed tip end portions of the internal conductor portion 59. The foregoing has explained the configurations of the joint devices 51 to 53. Next, the other components will be explained.

The high-voltage cable **70** is a member configured to connect the high voltage devices with each other and transmit a high-voltage current. As shown in FIGS. **2** to **4**, the high-voltage cable **70** is mainly constituted by a cable main body **71** and the cable connector portion **72** provided at a tip end portion of the cable main body **71**. The outer diameter of the cable main body **71** of the high-voltage cable **70** used in the high voltage device system **100** of the railcar **10** is about 50 to 60 mm, and the high-voltage cable **70** is extremely hard. Therefore, the high-voltage cable **70** is difficult to bend with a small bending radius. The cable connector portion **72** includes a concave accommodating portion **73** in which the joint connector portion **55** can be accommodated.

The cable connector portion **72** will be more specifically explained. The cable connector portion **72** is mainly constituted by a housing portion **74**, a connecting terminal **75**, a cap portion **76**, and an insulating plug **84**. The housing portion **74** includes a cylindrical fit tubular portion **77** and a cylindrical base tubular portion **78** which extends from a side surface of the fit tubular portion **77** in a direction perpendicular to the fit tubular portion **77** and is coupled to the fit tubular portion **77** such that the inside thereof communicates with the inside of the fit tubular portion **77**. The housing portion **74** has a T shape as a whole. One end of the fit tubular portion **77** is a connector opening portion **79** into which the joint connector portion **55** is inserted. The accommodating portion **73** having a concave shape is formed by the connector opening portion **79** and its vicinity. The other end of the fit tubular portion **77** is a work opening portion **80** used to perform a below-described connecting work. Further, the cable main body **71** having the tip end portion that has been stripped stepwise in advance is inserted through the base tubular portion **78** toward the inside of the housing portion **74**, and the connecting terminal **75** is attached to the tip end of the cable main body **71**. The housing portion **74** is made of an elastic insulating material, such as ethylene propylene rubber (EP rubber) or silicone rubber. Although not shown, an inner semi-conducting layer is formed on an inner peripheral side of a central portion of the housing portion **74** such that the inner semi-conducting layer covers the vicinity of the connecting terminal **75** and an inner peripheral side of the inner semi-conducting layer is exposed, and an outer semi-conducting layer is formed on an outer periphery of the housing portion **74**. The inner semi-conducting layer and the outer semi-conducting layer are formed integrally with the housing portion **74**, and the configurations of these layers are known to those skilled in the art (see Japanese Laid-Open Patent Application Publication No. 9-308075 and Japanese Laid-Open Patent Application Publication No. 2004-96929, for example). The inner semi-conducting layer is made of semi-conducting ethylene propylene rubber (EP rubber) or semi-conducting silicone rubber, and the external semi-conducting layer is made of semi-conducting or conducting paint, semi-conducting ethylene propylene rubber (EP rubber), or semi-conducting silicone rubber. The connecting terminal **75** is joined to a cable conductor **81** of the cable main body **71** by compression. The connecting terminal **75** is located inside the housing portion **74** (fit tubular portion **77**) and includes a compressed portion having an annular shape and a tip end portion having a plate shape. The insulating plug **84** includes an insulating plug main body **84***a*, a fixing embedded metal fitting **84***b*, and a work embedded metal fitting **84***c*. The insulating plug main body **84***a* is made of a hard insulating body, such as epoxy resin. The fixing embedded metal fitting **84***b* which is made of metal is embedded in the insulating plug main body **84***a* such that a tip end surface thereof is exposed at a tip end side of the insulating plug main body **84***a*. The work embedded metal fitting **84***c* which is made of metal is embedded in the insulating plug main body **84***a* such that a rear end portion thereof is exposed at a rear end side (a side where the cap portion **76** is attached) of the insulating plug main body **84***a*. A groove for accommodating a nut member **83** and an internal thread for fixing an external thread member **82** are formed at a tip end portion of the fixing embedded metal fitting **84***b*. After the insulating plug **84** is fitted to the work opening portion **80** of the fit tubular portion **77**, the cap portion **76** is attached to close the work opening portion **80**. Both the cap portion **76** and the insulating plug **84** are detachable. Each of the housing portion **74** and the cap portion **76** is made of an elastic insulating material. In a state where the plate-shaped tip end portion of the connecting terminal **75** is exposed in the accommodating portion **73** of the fit tubular portion **77**, the cable main body **71** and the cable connector portion **72** are integrally fixed to each other. The foregoing has explained the respective components of the high voltage device system **100** according to the present embodiment.

In the foregoing, the projecting directions of the joint connector portions **55** of the joint devices **51** to **53** have been specifically explained. However, the projecting directions of the joint connector portions **55** are not limited to the above directions. For example, four joint connector portions **55** of the X joint device **51** may be configured to project in different directions.

Connecting Method

Next, the method of connecting the high-voltage cables **70** to the joint devices **51** to **53** will be explained in reference to FIG. **5**. FIG. **5** is an exploded view showing the vicinity of the joint connector portion **55** and cable connector portion **72** according to the present embodiment. Here, the X branch joint device **51**, the Y branch joint device **52**, and the straight joint device **53** respectively include the joint connector portions **55** that are the same in configuration as one another, and the high-voltage cables **70** are connected to the respective joint devices **51** to **53** via the joint connector portions **55** in accordance with the same method. Therefore, the method of connecting the high-voltage cables **70** to the joint devices **51** to **53** will be explained as follows regardless of the types of the joint devices **51** to **53**.

First, the external thread member (stud) **82** is attached to the joint device **51**, **52**, or **53**. Specifically, the external thread member **82** made of metal is threadedly engaged with the internal thread **57** formed at the tip end portion of the internal conductor portion **56**, **58**, or **59** of the joint device **51**, **52**, or **53**. The length of the external thread member **82** is larger than the depth of the internal thread **57** formed at the internal conductor portion **56**, **58**, or **59**. Therefore, in a case where one end of the external thread member **82** is threadedly engaged with the internal thread **57**, a part of the other end of the external screw member **82** projects from the joint connector portion **55**.

Next, the cable connector portion **72** is fitted to the joint connector portion **55**. A direction in which the housing portion **74** of the cable connector portion **72** is fitted to the joint connector portion **55** is not a longitudinal direction of the high-voltage cable **70** but a direction substantially perpendicular to the longitudinal direction of the high-voltage cable **70**. More specifically, the joint connector portion **55** is accommodated in the accommodating portion **73** of the fit tubular portion **77** in such a manner that the housing portion **74** covers the tip end of the joint connector portion **55**. At this time, the external thread member **82** projecting from the joint connector portion **55** is caused to penetrate through a through hole **75***a* of the connecting terminal **75** that has been fixed in

advance so as to be exposed to the inside of the accommodating portion **73** of the fit tubular portion **77**.

Next, the nut member **83** made of metal is inserted through the work opening portion **80** formed in the fit tubular portion **77** of the housing portion **74**. To fix the connecting terminal **75** to the internal conductor portion **56**, **58**, or **59**, the nut member **83** is tightened on the external thread member **82** having penetrated through the connecting terminal **75**. Then, the insulating plug **84** is attached. Since this work can be performed through the work opening portion **80**, the work efficiency is extremely high.

Finally, the cap portion **76** is fitted to the work opening portion **80** to close the work opening portion **80**. With this, the high-voltage cable **70** and the joint device **51**, **52** or **53** are connected to each other. As above, the high voltage device system **100** according to the present embodiment is configured such that the high-voltage cables **70** are attached to the joint devices **51** to **53** by fitting the cable connector portion **72** to the joint connector portion **55** in a direction substantially perpendicular to the longitudinal direction of the high-voltage cable **70**. Therefore, the work performed in the case of the conventional prefabricated joint, that is, the work of pulling back the high-voltage cable **70** in the longitudinal direction is unnecessary. Thus, the high-voltage cables **70** can be easily connected to the joint devices **51** to **53**. In the case of the conventional prefabricated joint, the weight of the high voltage device system of the railcar is large due to, for example, a metal compression unit for pressing a stress-relief cone against a receiving opening. However, by adopting a connector type joint in which the number of parts is small as in the present embodiment, for example, the compression unit that is large in weight as in the case of the prefabricated joint is unnecessary. Thus, the weight of the high voltage device system of the railcar can be reduced. Therefore, the weight of the railcar can be reduced.

Wiring

Next, the wiring of the high-voltage cables **70** around the X branch joint device **51** in the railcar will be explained in reference to FIG. **6**. Here, FIG. **6** is a plan view showing the vicinity of the power collector **30** according to the present embodiment and is a diagram in which the collector shoe **31** and arm portion **32** of the power collector **30** are omitted. As shown in FIG. **6**, the cable connector portion **72** of the high-voltage cable **70** extending toward the power collector **30** is fitted to the first joint connector portions **55***a* located on a right rear side among the four joint connector portions **55** of the X branch joint device **51**. The cable connector portion **72** of the high-voltage cable **70** extending through the fifth car **15** to be connected to the breaker **40** of the sixth car **16** is fitted to the second joint connector portions **55***b* located on a left rear side. The cable connector portion **72** of the high-voltage cable **70** extending through a front surface of the fourth car **14** to be connected to the breaker **40** arranged under the floor of the fourth car **14** is fitted to the first joint connector portions **55***a* located on a right front side. The cable connector portion **72** of the high-voltage cable **70** extending through the third car **13** to be connected to the breaker **40** of the second car **12** is fitted to the second joint connector portions **55***b* located on a left front side. As can be understood from the above configuration, in the present embodiment, in order to supply the electric power obtained by the power collector **30** to the motors **18** through the breakers **40** mounted on the second car **12**, the fourth car **14**, and the sixth car **16**, the high-voltage cable **70** extending from the power collector is branched (is triply branched) at the X branch joint device **51** into three high-voltage cables **70**.

The following will compare FIG. **6** with FIG. **7** corresponding to FIG. **6** and showing a conventional case. In the conventional case, two high-voltage cables **270** extend from the power collector **230**. However, in the present embodiment, one high-voltage cable **70** extends from the power collector **30**.

As above, when wiring the conventional high-voltage cables, the Y branch joint device **252** that is a two-branch prefabricated joint is used. Therefore, to supply the electric power from the power collector **230** to three places, two high-voltage cables **270** need to be respectively arranged at the front and rear sides of the power collector **230**. Therefore, conventionally, one of two high-voltage cables **270** needs to be arranged so as to U-turn. On this account, a space corresponding to a bending radius of the high-voltage cable **270** for the U-turn and a space for the work of pulling back the high-voltage cable **270** when assembling the prefabricated joint need to be secured. Further, the high-voltage cable **270** needs to be increased in length for the U-turn. However, by using the X branch joint device **51** as in the present embodiment, it becomes unnecessary to cause the high-voltage cable **70** to U-turn, so that the high-voltage cable can be shortened.

Further, according to the joint devices **51** to **53** of the present embodiment, the high-voltage cables **70** can be connected to the joint devices **51** to **53** without pulling back the high-voltage cables **70** in the longitudinal direction. Therefore, even if the extra lengths of the high-voltage cables **70** are short, the high-voltage cables **70** can be connected to the joint devices **51** to **53**. Therefore, it is unnecessary to lengthen the high-voltage cable **270** between the power collector **230** and the joint device **252** beyond necessity, and it is also unnecessary to wire the high-voltage cable **270** with the large bending radius as shown in FIG. **7**. To be specific, in a case where the electric power is supplied from the power collector **30** to three places, and the joint device is located in the vicinity of the power collector **30** as shown in FIG. **6**, the X branch joint device **51** according to the present embodiment is used as the joint device. With this, the high-voltage cable **70** can be made shorter than the conventional cable. Therefore, the weight of the high voltage device system **100** of the railcar can be reduced by the reduction in length of the high-voltage cable **70**. In addition, instead of the conventional prefabricated joint which requires the stress-relief cone compression unit made of metal and in which the number of parts is large, by applying the connector type joint in which the number of parts is small and which is lightweight to the railcar, the high voltage device system **100** of the railcar can be significantly reduced in weight.

Next, the wiring of the high-voltage cables **70** around the Y branch joint device **52** will be explained in reference to FIG. **3**. To be specific, the cable connector portion **72** of the high-voltage cable **70** connected to the breaker **40** arranged under the floor of the sixth car **16** is fitted to the third joint connector portion **55***c* located on a right front side among three joint connector portions **55** of the Y branch joint device **52**. The cable connector portion **72** of the high-voltage cable **70** extending through the fifth car **15** to be electrically connected to the X branch joint device **51** of the fourth car **14** is fitted to the fourth joint connector portion **55***d* located on a left front side. The high-voltage cable **70** is not connected to the third joint connector portion **55***c* located on a right rear side. As above, the high-voltage cables **70** (cable connector portions **72**) are not necessarily connected to all the joint connector portions **55**. Therefore, the Y branch joint device **52** of the sixth car **16** may be replaced with the X branch joint device **51**. In this case, for example, the high-voltage cables **70** may not be connected to the joint connector portions **55** located on

a right rear side and a left rear side, and those unused joint connector portions **55** may be closed by, for example, insulating caps.

The foregoing has explained the embodiment of the present invention in reference to the drawings. However, the specific configurations are not limited to the above embodiment. Design modifications and the like may be made within the spirit of the present invention. For example, the present embodiment has explained the housing portion **74** having a T shape. However, the housing portion may have an L shape that does not include the work opening portion **80**, that is, does not require the insulating plug **84**.

In the present embodiment, the number of cars of the railcar is seven. However, the number of cars may be seven or more or seven or less. The power collector, the breaker, and the transformer have been explained as examples of the high voltage devices. However, design modifications, such as the number of high voltage devices, the types of the high voltage devices, the locations of the high voltage devices, the number of joint devices, the types of the joint devices, and the locations of the joint devices, may be made in the present invention. For example, the present invention also includes a case where both the joint device according to the present invention and the conventional joint device are used in the high voltage device system.

INDUSTRIAL APPLICABILITY

According to the high voltage device system of the railcar of the present invention, the high-voltage cable can be efficiently connected to the joint device even in a limited space, such as a space on the roof of the railcar. Therefore, the present invention is useful in a technical field of the high voltage device system of the railcar.

REFERENCE SIGNS LIST

10 railcar
18 motor
19 drive wheel
30 power collector
40 breaker
51 X branch joint device
52 Y branch joint device
53 straight joint device
55 joint connector portion
55*a* first joint connector portion
55*b* second joint connector portion
55*c* third joint connector portion
55*d* fourth joint connector portion
55*e* fifth joint connector portion
70 high-voltage cable
72 cable connector portion
73 accommodating portion
74 housing portion
75 connecting terminal
76 cap portion
77 fit tubular portion
78 base tubular portion
80 work opening portion
81 cable conductor
84 insulating plug
100 high voltage device system

The invention claimed is:

1. A high voltage device system for use with a railcar and at least one overhead contact line, the high voltage device system comprising:

a plurality of high voltage devices to which high-voltage electric power from the at least one overhead contact line is supplied;

a plurality of high-voltage cables configured to connect the high voltage devices with one another; and

a joint device to which the high-voltage cables are connected, wherein:

the high-voltage cables respectively each include cable connector portions at tip end portions of the high-voltage cables, each of the cable connector portions including: (i) a base tubular portion configured to cover the high-voltage cable, and (ii) a fit tubular portion extending from the base tubular portion in a direction substantially perpendicular to a longitudinal direction of the high-voltage cable;

the joint device includes joint connector portions, each of which is fitted to the fit tubular portion of the cable connector portion to be connected to the high-voltage cable; and

the joint connector portions of the joint device are four projecting joint connector portions.

2. The high voltage device system of the railcar according to claim **1**, wherein:

the four joint connector portions are two first joint connector portions projecting toward one side in the substantially railcar width direction and two second joint connector portions projecting toward the other side in the substantially railcar width direction;

the first joint connector portions are respectively arranged on front and rear sides in a railcar longitudinal direction; and

the second joint connector portions are respectively arranged on front and rear sides in the railcar longitudinal direction.

3. The high voltage device system of the railcar according to claim **2**, wherein:

the high-voltage cable extending from one of the high voltage devices is connected to one of the first joint connector portions; and

the electric power supplied from the high-voltage cable is supplied to the other first joint connector portion and the two second joint connector portions.

4. The high voltage device system of the railcar according to claim **2**, wherein:

the high voltage device system is applicable to the railcar including a bogie arranged under a floor thereof;

the high voltage devices include a power collector arranged at a substantially center of the bogie and on the roof of the railcar and configured to collect the electric power from the at least one overhead contact line;

the joint device is arranged so as to be located closer to an end portion in the railcar longitudinal direction than the power collector;

the cable connector portion of the high-voltage cable extending from the power collector is connected to one of the first joint connector portions; and

the electric power supplied from the high-voltage cable through the power collector is supplied to the other first joint connector portion and the two second joint connector portions.

5. The high voltage device system of the railcar according to claim **4**, wherein:

the high voltage device system is applicable to the railcar including a plurality of cars;

the cable connector portion of the high-voltage cable extending from the power collector is connected to one of the first joint connector portions; and

the high voltage devices other than the power collector are connected to the other first joint connector portion and the two second joint connector portions; and

at least one of the high voltage devices other than the power collector is arranged under a floor of the car other than the car including the power collector.

6. A high voltage device system for use with a railcar and at least one overhead contact line, the high voltage device system comprising:

a plurality of high voltage devices to inch high-voltage electric power from the at least one overhead contact line is supplied;

a plurality of high-voltage cables configured to connect the high voltage devices with one another; and

a joint device to which the high-voltage cables are connected. wherein:

the high-voltage cables respectively each include cable connector portions at tip end portions of the high-voltage cables, each of the cable connector portions including: (i) a base tubular portion configured to cover the high-voltage cable, and (ii) a fit tubular portion extending from the base tubular portion in a direction substantially perpendicular to a longitudinal direction of the high-voltage cable;

the joint device includes joint connector portions, each of which is fitted to the fit tubular portion of the cable connector portion to be connected to the high-voltage cable;

the joint connector portions of the joint device are two third joint connector portions projecting toward one side in a substantially railcar width direction and one fourth joint connector portion projecting toward the other side in the substantially railcar width direction; and

the third joint connector portions are respectively arranged on front and rear sides in a railcar longitudinal direction.

7. A high voltage device system for use with a railcar and at least one overhead contact line, the high voltage device system comprising:

a plurality of high voltage devices to which high-voltage electric power from the at least one overhead contact line is supplied;

a plurality of high-voltage cables configured to connect the high voltage devices with one another, and

a joint device to which the high-voltage cables are connected, wherein:

the high-voltage cables respectively each include cable connector portions at tip end portions of the high-voltage cables, each of the cable connector portions including: (i) a base tubular portion configured to cover the high-voltage cable, and (ii) a fit tubular portion extending from the base tubular portion in a direction substantially perpendicular to a longitudinal direction of the high-voltage cable;

the joint device includes joint connector portions, each of which is fitted to the fit tubular portion of the cable connector portion to be connected to the high-voltage cable;

each of the cable connector portions further includes a connecting terminal located inside the fit tubular portion and coupled to a cable conductor of the high-voltage cable;

the joint device includes an internal conductor portion exposed from tip ends of the respective joint connector portions;

in a state where the joint connector portions are fitted to the cable connector portions, the connecting terminals of the cable connector portions are electrically connected to the internal conductor portion at the joint connector portions; and

a work opening portion for connecting the connecting terminal and the internal conductor portion is formed at one side of the fit tubular portion of the cable connector portion, said one side is opposite to a portion in which the joint connector portion is accommodated.

8. The high voltage device system of the railcar according to claim **7**, wherein the cable connector portion includes an insulating plug configured to close the work opening portion.

9. A railcar for use with at least one overhead contact line, the railcar comprising:

high voltage devices that are a power collector configured to collect high-voltage electric power from the at least one overhead contact line, a breaker configured to break a circuit when a predetermined current or a current higher than the predetermined current from the power collector flows therethrough, and a transformer configured to transform a voltage of the current having flowed through the breaker;

a plurality of high-voltage cables configured to connect the high voltage devices with one another; and

a joint device to which the respective high-voltage cables are connected, wherein:

the high-voltage cables respectively include cable connector portions at tip end portions thereof, each of the cable connector portions including a base tubular portion configured to cover the high-voltage cable and a fit tubular portion extending from the base tubular portion in a direction substantially perpendicular to a longitudinal direction of the high-voltage cable;

the joint device includes joint connector portions, each of which is fitted to the fit tubular portion of the cable connector portion to be connected to the high-voltage cable; and

the joint connector portions of the joint device are four projecting joint connector portions.

10. A railcar for use with at least one overhead contact line, the railcar comprising:

high voltage devices that are a power collector configured to collect high-voltage electric power from the at least one overhead contact line, a breaker configured to break a circuit when a predetermined current or a current higher than the predetermined current from the power collector flows therethrough, and a transformer configured to transform a voltage of the current having flowed through the breaker;

a plurality of high-voltage cables configured to connect the high voltage devices with one another; and

a joint device to which the respective high-voltage cables are connected, wherein:

the high-voltage cables respectively include cable connector portions at tip end portions thereof, each of the cable connector portions including a base tubular portion configured to cover the high-voltage cable and a fit tubular portion extending from the base tubular portion in a direction substantially perpendicular to a longitudinal direction of the high-voltage cable;

the joint device includes joint connector portions, each of which is fitted to the fit tubular portion of the cable connector portion to be connected to the high-voltage cable;

the joint connector portions of the joint device are two third joint connector portions projecting toward one side in a substantially railcar width direction and one fourth joint

connector portion projecting toward the other side in the substantially railcar width direction; and

the third joint connector portions are respectively arranged on front and rear sides in a railcar longitudinal direction.

11. A railcar for use with at least one overhead contact line, the railcar comprising:

high voltage devices that are a power collector configured to collect high-voltage electric power from the at least one overhead contact line, a breaker configured to break a circuit when a predetermined current or a current higher than the predetermined current from the power collector flows therethrough, and a transformer configured to transform a voltage of the current having flowed through the breaker;

a plurality of high-voltage cables configured to connect the high voltage devices with one another; and

a joint device to which the respective high-voltage cables are connected, wherein:

the high-voltage cables respectively include cable connector portions at tip end portions thereof, each of the cable connector portions including a base tubular portion configured to cover the high-voltage cable and a fit tubular portion extending from the base tubular portion in a direction substantially perpendicular to a longitudinal direction of the high-voltage cable;

the joint device includes joint connector portions, each of which is fitted to the fit tubular portion of the cable connector portion to be connected to the high-voltage cable;

each of the cable connector portions further includes a connecting terminal located inside the fit tubular portion and coupled to a cable conductor of the high-voltage cable;

the joint device includes an internal conductor portion exposed from tip ends of the respective joint connector portions;

in a state where the joint connector portions are fitted to the cable connector portions, the connecting terminals of the cable connector portions are electrically connected to the internal conductor portion at the joint connector portions; and

a work opening portion for connecting the connecting terminal and the internal conductor portion is formed at one side of the fit tubular portion of the cable connector portion, said one side is opposite to a portion in which the joint connector portion is accommodated.

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